

## Claims

What is claimed is:

1. A method of adhering a ruthenium metal layer to an oxide layer of a semiconductor, the method comprising:
  - exposing the oxide layer to a silicon-containing gas selected from the group consisting of silane, disilane, and methylated silanes; and
  - after exposing the oxide layer to the silicon-containing gas, forming the ruthenium metal layer to contact the oxide layer.
2. The method of claim 1 further comprising forming the ruthenium metal layer 60 minutes or less after exposing the oxide layer to the silicon-containing gas.
3. The method of claim 1 further comprising forming the ruthenium metal layer 10 minutes or less after exposing the oxide layer to the silicon-containing gas.
4. A method of adhering a ruthenium metal layer to an oxide layer of a semiconductor, the method comprising:
  - exposing the oxide layer to a silicon-containing gas to convert a surface termination of the oxide layer from a hydroxyl-terminated surface to a hydrogen-terminated surface; and
  - after exposing the oxide layer to the silicon-containing gas, forming the ruthenium metal layer to contact the oxide layer.
5. The method of claim 4 further comprising forming the ruthenium metal layer 60 minutes or less after exposing the oxide layer to the silicon-containing gas.

6. The method of claim 4 further comprising forming the ruthenium metal layer 10 minutes or less after exposing the oxide layer to the silicon-containing gas.

7. A method for forming a semiconductor device, comprising:

providing an oxide layer as part of a semiconductor wafer substrate assembly;

placing the semiconductor wafer substrate assembly into a deposition chamber;

flowing a silicon-containing gas into the deposition chamber to expose the oxide layer to the silicon-containing gas; and

subsequent to exposing the oxide layer to the silicon-containing gas, flowing a ruthenium metal precursor into the deposition chamber to form a ruthenium metal layer on the oxide layer.

8. The method of claim 7 wherein the flowing of the silicon-containing gas into the deposition chamber comprises flowing a gas selected from the group consisting of silane, disilane, and methylated silanes.

9. The method of claim 7 wherein the flowing of the ruthenium metal precursor into the deposition chamber comprises flowing a gas selected from the group consisting of tricarbonyl cyclohexadiene ruthenium, bis(cyclopentadienyl) ruthenium, and a derivative of ruthenocene.

10. The method of claim 7 further comprising flowing helium into the deposition chamber concurrently during the flowing of the ruthenium metal precursor into the deposition chamber.

11. The method of claim 7 wherein the oxide layer is silicon dioxide.
12. The method of claim 7 wherein the oxide layer comprises an oxide selected from the group consisting of metal oxide and mixed metal oxide.
13. The method of claim 7 wherein the oxide layer comprises an oxide selected from the group consisting of hafnium oxide, aluminum oxide, tantalum pentoxide, barium strontium titanate, titanium oxide, yttrium aluminum oxide, and aluminum hafnium oxide.
14. The method of claim 7 further comprising maintaining a thickness of the oxide layer such that subsequent to the exposure of the oxide layer to the silicon-containing gas the oxide layer is not thicker than prior to the exposure to the silicon-containing gas, and the exposure to the silicon-containing gas does not form a separate layer of material on the oxide layer.
15. The method of claim 7 further comprising forming the ruthenium metal layer 60 minutes or less after exposing the oxide layer to the silicon-containing gas.
16. The method of claim 7 further comprising forming the ruthenium metal layer 10 minutes or less after exposing the oxide layer to the silicon-containing gas.

17. The method of claim 7 further comprising:

flowing the ruthenium metal precursor into the deposition chamber for a duration of between about 0.1 milliseconds and about 10 seconds;

subsequent to flowing the ruthenium metal precursor into the deposition chamber, purging the ruthenium metal precursor from the chamber for between about 1 second and about 60 seconds; then

repeating the flow of the ruthenium metal precursor into the deposition chamber and the purging of the ruthenium metal precursor from the chamber a sufficient number of times for form the ruthenium metal layer of a sufficient thickness.

18. The method of claim 17 further comprising performing the flow of the ruthenium metal precursor into the deposition chamber and the purge of the ruthenium metal precursor from the chamber for between about 10 cycles and about 300 cycles.

19. A method used to form a storage capacitor for a semiconductor device, comprising:

providing a semiconductor wafer substrate assembly comprising a conductive contact pad and a planarized dielectric layer over the conductive contact pad;

etching the dielectric layer to expose the conductive contact pad;

in a deposition chamber, flowing a silicon-containing gas to expose the oxide layer to the silicon-containing gas; and

subsequent to exposing the oxide layer to the silicon-containing gas, flowing a ruthenium metal precursor into the deposition chamber to form a ruthenium metal layer on the oxide layer and on the conductive contact pad.

20. The method of claim 19 wherein the flowing of the silicon-containing gas into the deposition chamber comprises flowing a gas selected from the group consisting of silane, disilane, and methylated silane.

21. The method of claim 20 further comprising:

flowing the silicon-containing gas into the deposition chamber at a flow rate of between about 1 standard cubic centimeter per minute (sccm) and about 100 sccm;

maintaining the semiconductor wafer substrate assembly at a temperature of between about 150°C and about 350°C during the flow of the silicon-containing gas into the deposition chamber; and

flowing the silicon-containing gas into the deposition chamber for a duration of between about 10 seconds and about 120 seconds.

22. The method of claim 19 wherein the flowing of the ruthenium metal precursor into the deposition chamber comprises flowing a gas selected from the group consisting of tricarbonyl cyclohexadiene ruthenium, bis(cyclopentadienyl) ruthenium, and a derivative of ruthenocene.

23. The method of claim 19 wherein the flowing of the ruthenium metal precursor into the deposition chamber comprises flowing a gas selected from the group consisting essentially of tricarbonyl cyclohexadiene ruthenium, bis(cyclopentadienyl) ruthenium, and derivatives of ruthenocene.

24. The method of claim 19 further comprising forming a ruthenium metal layer between about 50 angstroms (Å) and about 200 Å during the flow of the ruthenium metal precursor into the deposition chamber.

25. The method of claim 24 further comprising:

flowing the ruthenium metal precursor into the deposition chamber at a flow rate of between about 0 standard cubic centimeters per minute (sccm) and about 1,000 sccm;

maintaining the semiconductor wafer substrate assembly at a temperature of between about 100 °C and about 500 °C during the flow of the ruthenium metal precursor into the deposition chamber;

maintaining the deposition chamber at a pressure of between about 1 Torr and about 5 Torr during the flow of the ruthenium metal precursor into the deposition chamber; and

flowing the ruthenium metal precursor into the deposition chamber for a duration of between about 30 seconds and about 8 minutes.

26. A method used to form a semiconductor device, comprising:

providing a semiconductor wafer substrate assembly comprising an oxide layer having a hydroxyl-terminated surface termination;

placing the semiconductor wafer substrate assembly into a deposition chamber;

in the deposition chamber, exposing the oxide layer to a silicon-containing gas selected from the group consisting of silane, disilane, and methylated silanes to alter the surface termination from the hydroxyl-termination to a hydrogen-terminated surface termination;

within 60 minutes or less of exposing the oxide layer to the silicon-containing gas, and within the deposition chamber, exposing the oxide layer to a ruthenium metal precursor selected from the group consisting of tricarbonyl cyclohexadiene ruthenium, bis(cyclopentadienyl) ruthenium, and a derivative of ruthenocene to form a ruthenium metal layer on at least the portion of the oxide layer exposed to the silicon-containing gas.